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Post-Harvest Fungicidal Treatments of Peaches Tested in 1951

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Division of Handling, Transportation and Storage of Horticultural Crops

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Tests with fungicides for post-harvest treatment of peaches have been made by the Department during the past four seasons. A preliminary report of results obtained in 1950 was made at the 1950 Shenandoah-Cumberland Fruit Workers Conference. 2/ During the 1951 season additional tests were made with some of the more promising materials used in 1950 and with additional materials.

Materials and Methods

The tests were made at the Horticultural Field Station at Fort Valley, Ga. with peaches grown near Fort Valley and at the Plant Industry Station at Beltsville, Md. with peaches from an orchard near Martinsburg, W. Va. Peaches for the tests were obtained from packing sheds and represented the maturity being shipped commercially, except that any peaches that were beginning to soften were sorted out in making up the test samples. The experimental treatments were applied one day after picking. Individual samples usually consisted of 50 peaches and each treatment was applied to a non-inoculated sample, to a sample inoculated with spores of Monilinia fructicola (Wint.) Honey (brown rot) and to a sample inoculated with spores of Rhizopus nigricans Fr. Brown rot and rhizopus rot due to natural infection was very low on most of the experimental lots used in 1951, consequently significant differences from the fungicidal treatment were obtained only with artificially inoculated fruit and results are presented for the inoculated lots only.

Peaches inoculated with Monilinia spores were sprayed lightly on both sides with a suspension of the spores in a solution of about 10 percent peach juice in water. At Fort Valley this was done by laying the sample of peaches in one layer on a table and spraying the exposed side with an atomizer. The fruit was then turned over and the other side sprayed. At Beltsville a roller table was available and the fruit was sprayed as it revolved. No attempt was made to completely wet the fruit with the spore suspension but each fruit was sprayed the same length of time in order to have as uniform coverage as possible.

1/ Report of study under R&MA of 1946, RM:c-553, Develop methods of handling and shipping peaches to widen distribution of fruit ripened to higher quality.

2/ Haller, M. H., Smith, M. A., Womeldorph, S. E. Jr. and Smith, W. L. Jr. Post-harvest treatments for the control of decay on peaches. Proc. Cumberland-Shenandoah Fruit Workers Conf. 26 (1950): 5 pp. Processed.

Preliminary tests indicated that Rhizopus infection could not be obtained consistently through the uninjured skin of the peach. Therefore, peaches to be inoculated with Rhizopus spores were first injured by six shallow, sterile pin pricks. They were then sprayed with a suspension of Rhizopus spores in the same manner as described above for Monilinia. The Rhizopus spores were suspended in water to which a wetting agent (0.2 percent Tween-20) was added. The spore suspensions were at a concentration such that a drop of the suspension showed 40 to 60 spores in the low power field of a microscope. It was roughly estimated that at least 1,000 spores were applied to each inoculated peach.

Fungicidal treatments were applied within a period of 1 to 5 hours after inoculation. Fungicides in liquid form were sprayed on the fruit in the same manner as spore suspensions except that an attempt was made to wet the entire surface of the fruit with the fungicide but with little or no run-off. A wetting agent was added to most of the solutions to facilitate wetting. Dust fungicides were applied by covering the fruit with a box-like hood, blowing the dust into the hood for 15 seconds and allowing it to settle for 1 minute before the hood was removed. Fumigation treatments were applied in metal chambers of 10 cubic feet capacity. Each chamber was equipped with an electric hot plate to vaporize materials with high boiling points and a small fan to facilitate circulation of the gas. The peaches were at room temperature during the periods of fumigation.

In earlier experiments it was observed that, although examinations were made at intervals of 2 days and rotted fruit discarded at each examination, there was frequently much nesting in the case of rhizopus rot. This resulted in great variability in counts of rhizopus rot in replicate lots, which made it difficult to obtain significant differences between treatments. Nesting from natural infection of Rhizopus also interferred with brown rot counts in some samples inoculated with Monilinia spores. In addition it was thought that fungicidal treatments might be expected to reduce rhizopus rots due to primary infections but could hardly be expected to prevent its spread by nesting. For these reasons it seemed desirable to prevent the nesting of Rhizopus. This was very largely accomplished by individually wrapping the peaches in all of the experimental samples in copper impregnated wraps such as are used on pears to prevent the nesting by Botrytis. The effectiveness of the wraps was indicated by a test in which a single peach inoculated with Rhizopus spores was placed in the center of each of six half bushel baskets of peaches. After 5 days at room temperature the Rhizopus had spread throughout the 2 baskets in which the fruit was naked and in the 2 baskets in which the peaches were wrapped in plain tissue wraps the Rhizopus had spread through more than half of the basket with only part of the fruit on top still sound. In contrast to this the Rhizopus had spread to only 4 or 5 peaches in immediate contact with the inoculated peach in the 2 baskets in which the peaches were wrap ed in copper impregnated paper. Although wraps were used in these studies as a part of the experimental technique the results indicate that they may be useful in commercial shipments, particularly in the west where plain wraps are now used. Even in the central and eastern states the possible reduction in decay by their use would seem to justify the increased cost of wrapping.

Following inoculation and fungicidal treatment the samples were held in half bushel baskets at room temperature. At Fort Valley a basement room was used in which the temperature fluctuated between 75° and 85°F. At Beltsville a storage room was used in which a constant temperature of 75° was maintained.

Inspections were made at 2 day intervals with the final inspection after 6 days by which time most of the fruit was fully ripe. At each inspection the peaches that were fully eating ripe were discarded as well as those that were decayed. Thus the decay percentages given in the tables represent the cumulative decay during 6 days that occurred before the peaches became ripe. Decay due to organisms other than Monilinia and Rhizopus were recorded but they usually occurred only in small percentages and the influence of the fungicidal treatments on them could not be observed. Decay percentages on inoculated peaches did not become higher than on non-inoculated samples until the inspections made 4 days after treatment indicating that more than 2 days was necessary under these conditions for the inoculations to cause visible decay lesions.

Replication was obtained by repeating each series of tests at 4 different times using different lots of fruit. Two of the tests were conducted at Fort Valley and two at Beltsville.

Before trying a material for fungicidal effectiveness it was given preliminary tests to determine whether or not it would injure the fruit at concentrations contemplated for use in fungicidal tests. Data from these tests are not presented in tabular form but may be discussed in connection with presentation of fungicidal results.

Results

A description of the experimental fruit with the percentage of brown rot and rhizopus rot that developed from natural infection is given in table 1.

Decay percentages on inoculated peaches following the various fungicidal treatments are presented in tables 2 to 4. Brown rot due to natural infection on the 12 lots of fruit used as unsprayed checks in the 3 experiments averaged only 6.8 percent (table 1) and only 2 of the lots had more than 10 percent. Artificial inoculation increased the average brown rot in the checks over 10 fold to 75.8 percent (table 2-4) and varied from 46 to 100 percent. Rhizopus rot, due to natural infection, averaged 6.0 percent in the unsprayed checks (table 1) and only 2 of the 12 lots had more than 10 percent. Artificial inoculation increased the average rhizopus rot in these checks 5 fold to 30.7 percent. However, the percentage rot on the inoculated lots varied greatly with 3 lots having only 8 - 12 percent and one lot as high as 92 percent (tables 2-4).

The effectiveness of the various materials in controlling brown rot in these tests was as follows:-

Sulfur dust: The standard packing house treatment of dusting with sulfur for controlling decay of peaches was used in addition to untreated lots for comparison with other treatments in all our experiments in 1951. Certainly any treatment to be of commercial value would need to be as effective if not more effective than sulfur dust. In commercial packing house practice the sulfur dust is applied ahead of the brushes and much of the sulfur is brushed off with the fuzz. Our experimental lots were not brushed after dusting and consequently retained a heavier coating of sulfur than is normal commercially and therefore our control of brown rot with sulfur dust was probably better than would be expected commercially. On all 12 lots inoculated with Monilinia sulfur dust reduced brown rot from 75.8 percent on untreated lots

to 18.3 percent on the treated fruit. This is a reduction of 76 percent which agrees very well with results obtained the previous season.

Liquid lime sulfur: In the 1950 season a spray of liquid lime sulfur at a concentration of 1 to 200 was one of the more effective treatments used. It reduced brown rot on artificially inoculated lots as much as 68 to 90 percent. In the 1951 season it was used in 3 concentrations of 1 to 400, 1 to 200 and 1 to 100 (table 2). The most effective concentration was 1 to 200 which reduced the brown rot by 58 percent of the untreated lots but it was less effective than sulfur dust.

Wettable sulfur: In the 1950 season wettable sulfur was used as a 1 percent spray and was about equally as effective as liquid lime sulfur and sulfur dust. In 1951 it was used in 3 concentrations of 0.5, 1.0 and 2.0 percent (table 2). The effectiveness increased with the concentration but even at 2 percent brown rot was reduced by only 39 percent as compared with a 76 percent reduction with sulfur dust.

Orthocide 406 (N-trichloromethyl thio-tetrahydrophthalimide). In the 1950 season a 1 percent spray of Orthocide-406 reduced brown rot 49 and 99 percent and a 5 percent dust gave a reduction of 71 percent. In 1951 it was used as 1 and 2 percent sprays and as 2 and 5 percent dusts. Both spray concentrations were very effective, reducing the brown rot by 81 and 87 percent. This was not significantly more effective than the sulfur dust. Orthocide-406 was much less effective when used as a dust. In some of the tests this material left a visible residue both as a spray and as a dust.

Crag 5379 (N-S organic complex) In the 1950 season a 1 percent spray of this material reduced brown rot by 52 percent and a 2 percent spray reduced it by 90 percent but a 5 percent dust was ineffective. In the 1951 season it was used as a 1 and 2 percent spray and as a 2 and 5 percent dust. Greatest reduction of brown rot was obtained with the 2 percent spray but this treatment caused injury in some of the tests and usually left a visible residue. A 1 percent spray reduced brown rot by only 59 percent and was appreciably less effective than sulfur dust. Crag 5379 2 and 5 percent dusts were relatively ineffective.

DHA-S or dehydroacetic acid, sodium salt. (3-(1-hydroxyethylidene)-6-methyl - 2 H-pyran-2,4(3H)-dione, sodium salt). DHA-S as a 1 percent spray (table 3) reduced brown rot only about 50 percent but a 2 percent spray (table 4) gave a reduction of 83 percent. This was as effective as sulfur dust on comparable lots.

Dowicide A (Sodium orthophenylphenate) In the 1950 season a 1 percent Dowicide A spray caused injury. In the 1951 season hexamide which is used as a saftener for Dowicide A in treating citrus was tried with Dowicide A in treating peaches. A 1 percent spray of Dowicide A either with or without 1 percent hexamide caused injury and no injury occurred when Dowicide A was used at 0.5 percent concentration either with or without the hexamide. At 0.5 percent concentration Dowicide A reduced brown rot by 84 percent compared with untreated lots (table 4).

Isothan Q 15 (Lauryl isoquinolinium bromide). In preliminary tests a 2 percent spray of isothan Q 15 caused definite injury and there were slight indications of injury by a 1 percent spray. It was tested, therefore, at only 0.5 percent concentration at which it reduced brown rot by 84 percent.

The above treatments were among the most effective of those tried in reducing brown rot on artificially inoculated fruit. The following materials gave some reduction in brown rot but were appreciably less effective than sulfur dust and are considered to have little or no promise:

2 Amino pyridine - 1 and 2 percent sprays,
8 Quinolinol sulfamate - 1 percent spray,
Copper A (copper oxychlorides) - 1 percent spray,
Seedox (2,4,5 trichlorophenol acetate) - 2 percent spray,
Bisphenol A - 1 percent spray,
Nitrophenol carbonate - 1 percent spray,
Propylene glycol - 1 and 4 percent sprays,
Triethylene glycol - 1 and 4 percent sprays,
Crag 341 C (Mixed glyoxalidines) 1 percent spray,
Crag 531 (Ca.-Zn.-Cu.-Cd. chromates) 1 percent spray,
Crag 658 (Cu-Zn chromates) 1 percent spray,
Clorox - 1500 ppm. Cl. spray.

In addition to the above spray or dust applications a few fumigation tests were made with volatile materials with the following results.

<u>Ethylene dichloride</u>: In the 1950 season ethylene dichloride was used at concentrations of approximately 1 volume of liquid to 28,000 and 14,000 volumes of air for 20 hours. No injury was observed but the control of brown rot was poor. In 1951 a higher concentration of 1 to 7,000 was tried but this caused severe injury to the fruit.

<u>Trichlorethane</u>: In the 1950 season this material was used at a concentration of 1 to 28,000 for 5 hours without injury to the fruit but control of brown rot was poor. In 1951 the concentration was increased to 1 to 7,000 for 16 hours. At this concentration injury was very severe and no decay records were obtained. Vandemark and Sharvelle 3/ report complete inhibition of breakdown (presumably brown rot and rhizopus rot) with 1,1,2 trichlorethane at 1 to 10,000 for 24 hours. They indicate some injury at 1 to 4,000 but only slight browning at 1 to 10,000.

<u>Tetrachlor ethane</u>: In the 1950 season tetrachlor ethane, when used at a concentration of 1 - 28,000 for 19 hours, caused very severe injury (completely browned to the pit). In 1951 it was tried at 1 - 56,000 for 16 hours but even this concentration caused severe injury and no decay records could be made. Vandemark and Sharvelle 3/ report complete inhibition of decay with secondary tetrachlorethane at concentrations of 1 to 4000 and 1 to 10,000 but indicate some browning occurred.

<u>Pentachlor ethane</u>: In the 1950 season pentachlor ethane when used at 1 to 28,000 for 6 hours gave poor control of brown rot but did not cause injury. When the concentration was doubled to 1 to 14,000 for 16 hours in 1951 it caused severe injury.

3/ Vandemark, J. S. and Sharvelle, E. G. Prevention of post-harvest decay of stone fruits by volatile chemicals. Science 115: 149-150 Feb. 8, 1952.

Diphenyl: In the 1950 season very effective control of brown rot was obtained when peaches were packed in baskets completely lined with non-vented liners impregnated with diphenyl. However, the phenolylic odor was imparted to the fruit so that it became inedible. It was thought that a short exposure to the diphenyl might control the brown rot without imparting an off flavor to the fruit. In the 1951 season lots of peaches were placed in the metal chambers and 0.2 and 0.4 grams of diphenyl crystals per cubic foot were vaporized on the hot plates. Five to 10 minutes were required for vaporization after which the hot plates were disconnnected and the fans run for a short period. After 6 hours the peaches were removed from the chambers at which time a light coating of fine crystals, presumably diphenyl, could be observed on the surface of the fruit. This was sufficient to give the fruit an off flavor by the time it ripened. Furthermore, brown rot was not controlled by the treatment.

Control of rhizopus rot: Only 4 of the fungicidal treatments were sufficiently effective against Rhizopus to reduce the average rot caused by this fungus as much as 50 percent. These treatments were (1) 1 percent spray of 8 quinolinol sulfamate which caused a reduction of 70 percent, (2) 1 percent spray of Crag 658 which caused a reduction of 65 percent, (3) 1 percent spray of Crag 531 which caused a reduction of 51 percent and (4) 1 percent spray of Copper A which caused a reduction of 50 percent. These results can be compared with an average reduction of only 26 percent on the 12 lots dusted with sulfur. Because of the large variability in the rhizopus infections it is questionable whether treatment differences are of statistical significance.

Toxicity

In general tests were not made with materials that were known to be objectionable from the standpoint of human toxicity in the amounts likely to remain as residues on the fruit. However, many of the materials tested have not been approved by the Food and Drug Administration and this would be necessary before their commercial trial.

TABLE 1. Description of the peaches used in the tests of fungicides.

Expt. No.	Test Lot	Variety	Source	Date Picked	Natural infection Brown rot percent	Natural infection Rhizopus rot percent
3	A	Dixigem	Fort Valley, Ga.	June 13	2	2
	B	E. Hiley	Do.	June 21	2	18
	C	Redhaven	Martinsburg, W.Va.	Aug. 2	10	2
	D	Triogem	Do.	Aug. 13	17	6
4	A	E. Hiley	Fort Valley, Ga.	June 18	10	20
	B	Southland	Do.	June 27	28	6
	C	Triogem	Martinsburg, W.Va.	Aug. 6	0	2
	D	Sullivan Elberta	Do.	Aug. 20	4	0
8	A	E. Hiley	Fort Valley, Ga.	June 28	0	8
	B	Elberta	Do.	July 5	2	2
	C	Erly Red Fre	Martinsburg, W. Va.	July 17	7	5
	D	Elberta	Do.	Aug. 27	0	0
	Average				6.8	6.0

TABLE 2. Effect of post-harvest fungicidal treatments on development of brown rot and rhizopus rot on peaches held 6 days at 75 to 85° F. Fruit inoculated with Monilinia and Rhizopus spores. Experiment 3 - 1951.

Fungicidal treatment			Brown rot on test lot 1/					Rhizopus rot on test lot 1/				
Material	Conc.	Method	A %	B %	C %	D %	Av. %	A %	B %	C %	D %	Av. %
None	--	--	56	96	72	88	78.0	10	12	32	68	30.5
Sulfur	90%	Dust	10	24	20	20	18.5	8	14	24	68	28.5
Liq.lime sul.	1/400	Spray	24	88	74	62	62.0	2	34	58	58	38.0
Do.	1/200	Do.	22	50	16	42	32.5	20	14	42	80	39.0
Do.	1/100	Do.	24	60	58	56	49.5	38	26	58	48	42.5
Wettable Sul.	0.5%	Do.	16	100	82	76	68.5	12	32	48	54	36.5
Do.	1.0%	Do.	2	98	66	54	55.0	28	38	50	48	41.0
Do.	2.0%	Do.	14	84	48	44	47.5	18	28	46	50	35.5
Orthocide406	1.0%	Do.	8	30	14	6	14.5	18	22	84	70	48.5
Do.	2.0%	Do.	2	18	4	16	10.0	16	24	64	42	36.5
Do.	2.0%	Dust	18	94	48	64	56.2	6	42	60	14	30.5
Do.	5.0%	Do.	16	76	68	62	55.5	8	28	40	36	28.0
Crag 5379	1.0%	Spray	6	64	42	16	32.0	16	28	62	74	45.0
Do.	2.0%	Do.	12	28	28	12	20.0	24	18	26	28	24.0
Do.	2.0%	Dust	30	92	57	70	62.3	28	46	42	8	31.0
Do.	5.0%	Do.	36	70	74	46	56.5	18	14	28	36	24.0

1/ See table 1 for description of test lots.

TABLE 3. Effect of post-harvest fungicidal treatments on development of brown rot and rhizopus rot on peaches held 6 days at 75 to 85° F. Fruit inoculated with Monilinia and Rhizopus spores. Experiment 4 - 1951.

Fungicidal treatment			Brown rot on lot 1/					Rhizopus rot on lot 1/				
Material	Conc.	Method	A %	B %	C %	D %	Av. %	A %	B %	C %	D %	Av. %
None	--	--	90	90	78	100	89.5	22	18	92	8	35.0
Sulfur	90%	Dust	10	62	12	22	26.5	32	12	24	10	19.5
2 Amino-pyridine	1%	Spray	90	46	14	86	59.0	22	56	78	34	47.5
8-Quinolinol sulfamate	1%	Do.	76	38	76	78	67.0	8	20	6	8	10.5
Copper-A	1%	Do.	90	80	32	26	57.0	20	10	22	18	17.5
Seedox	2%	Do.	60	78	0	2	35.0	18	78	100	100	74.0
DHA-S	1%	Do.	74	32	26	46	44.5	8	6	38	40	23.0
Bisphenol A	1%	Do.	76	82	16	30	51.0	20	42	100	98	65.0
Nitrophenol carbonate	1%	Do.	32	62	32	24	37.5	54	50	98	94	74.0
Propylene glycol	1%	Do.	88	78	64	62	73.0	12	30	34	18	23.5
Triethylene glycol	1%	Do.	90	82	60	72	76.0	10	30	48	12	25.0
Crag 341C	1%	Do.	84	60	18	30	48.0	20	56	6	4	21.5
Crag 531	1%	Do.	78	72	32	62	61.0	12	30	14	12	17.0
Crag 658	1%	Do.	92	92	46	66	74.0	22	10	10	8	12.5
Clorox	1500 p.p.m.	Do.	74	82	30	42	57.0	10	52	14	10	21.5

1/ See table 1 for description of lots.

TABLE 4. Effect of post-harvest fungicidal treatments on development of brown rot and rhizopus rot on peaches held 6 days at 75 to 85° F. Fruit inoculated with Monilinia and Rhizopus spores. Experiment 8 - 1951.

Fungicidal treatment			Brown rot on lot 1/					Rhizopus rot on lot 1/				
Material	Conc.	Method	A %	B %	C %	D %	Av. %	A %	B %	C %	D %	Av. %
None	--	--	74	72	47	46	59.8	44	28	18	16	26.5
Sulfur	90%	Dust	2	22	13	2	9.8	38	10	12	20	20.0
Dowicide A	0.5%	Spray	16	16	10	6	9.5	40	26	12	20	24.5
Isothan Q15	0.5%	Do.	8	10	8	10	9.0	62	82	78	24	61.5
Proplylene-glycol	4.0	Do.	36	86	53	22	49.2	28	14	21	18	20.2
Triethylene-glycol	4.0	Do.	42	92	83	30	61.8	34	18	33	6	22.8
DHA-S	2.0	Do.	2	30	2	6	10.0	20	2	38	32	23.0
2 Amino-pyridine	2.0	Do.	28	52	30	16	31.5	54	18	38	18	32.0

1/ See table 1 for description of lots.